Altered thoracolumbar position during application of craniocaudal spinal mobilisation in clinically sound leisure horses

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Running header: **Effect of the CCSM technique on equine thoracolumbar spine kinematics**

Abstract

Manual therapy techniques are commonly used by physiotherapists in the management of back pain to restore a pain-free range of motion and function in humans. However, there is a lack of research to support the proposed kinematic effects of manual therapy in the horse. This study investigated the kinematic effects of craniocaudal spinal mobilisation (CCSM) on the thoracolumbar spine in asymptomatic leisure horses. Markers were fixed to T10, T13, T17, L1, L3, the highest point of the wither and the tuber sacrale on thirteen horses that were positioned squarely. The CCSM technique consisted of two parts: 1) carpal flexion of either forelimb to 90° to maintain the horse in a tripod position, and, 2) the application of a cranial to caudal force to the forehand via the ipsilateral point of the shoulder. Movement changes of the thoracolumbar markers from baseline to maximum flexion when the CCSM was applied was recorded as 'depth' (mm) relative to a fixed line drawn from the tuber sacrale to the maximal point of the withers. The change in angle (°) of each marker relative to the same markers was also recorded. Data were collected via video and analysed with Dartfish™ software. Increases in maximum thoracolumbar angle ($P<0.05$) and reductions in thoracolumbar depth ($P<0.05$) were found with CCSM. These results indicate CCSM induced flexion in the thoracolumbar spine, supporting its potential to improve range of motion and function in horses. Further studies to understand whether the changes observed during CCSM translate to treatment of back pain are warranted.

Keywords

Back pain, manual therapy, posture, veterinary physiotherapy, horse, spinal kinematics.

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Introduction

Back pain is a complex multifaceted condition that can adversely affect equine performance leading to a negative economic impact through days lost from training and competition, as well as reducing competitive success, financial reward and individual value (Seitzinger et al. 2001, Wischer, 2006). Exploration of the efficacy of techniques purported to reduce or eliminate back pain in horses would be advantageous and provide horse owners, keepers and trainers with an ability to make evidence informed judgements on how to ensure equine welfare is prioritised.

Manual therapy, defined as '*passive or assisted active movement techniques applied by the therapist to address pain and impairment of the articular, neural and muscular systems'* (Goff, 2009), has been advocated as a positive intervention to reduce equine back pain using analogous techniques to those applied in humans. Craniocaudal spinal mobilisation (CCSM) is a specific manual therapy technique described for use in humans by Petty (2004) but also used regularly in the rehabilitation of horses. In the horse, it is performed by applying an indirect manual force to the spine, in a caudal direction through the point of the shoulder of a non-weight bearing forelimb, maintained in ninety-degree carpal flexion (Supplementary file 1). Movement of the thoracolumbar spine from a position of relative extension into flexion, creates an elongating or stretching effect in associated dorsal spinal structures, including the dorsal spinal ligament and the epaxial musculature. Despite the anecdotal reports of this technique used in the treatment of horses, there has been no research to support the use of the CCSM as an effective technique. Therefore, this study hypothesised that the CCSM technique would generate flexion of the thoracolumbar spine.

Methodology

A convenience sample of horses (n = 13), used for leisure riding and unaffiliated competition, of mixed breed (4 warmbloods, 3 cobs, 4 New Forest ponies, 1 Thoroughbred and 1 Irish Draft), age (mean±standard deviation (SD): 10.9±4.4 years; range: 5 to 19 years) and height (mean±SD: 156.9± 9.2cm; range: 147.3cm to 167.6cm) participated in the study. All horses were stabled at the same livery yard and were subject to similar management regimes: stabled for 12 hours and turnout for 12 hours daily with ridden exercise approximately 60 to 90 minutes, 4 to 5 times per week. Horses with a history of back pain and / or other musculoskeletal disorders including lameness within the past 6 months, or were currently being administered analgesics such as phenylbutazone, or whose owners felt had experienced a reduction in performance levels in the previous 6 months, were excluded from the study. Owner and veterinary surgeon consent was obtained[1]. All procedures including marker fixation and manual therapy were approved as adhering to animal welfare guidelines by the University of the West of England (Hartpury) Ethics Committee and were performed by the same Chartered veterinary physiotherapist (FT).

Protocol

[1] Royal College of Veterinary Surgeon's Veterinary Surgery Act: Exemptions Order (2015)

Patient preparation

Prior to CCSM treatments, each horse was stood square on a level concrete floor with its head in a neutral position (Berner et al., 2012). Eight 25mm hemispherical polystyrene markers were applied to dorsal spinal processes (DSP at the highest point of the withers, T10, T13, T17, L1, L3, identified by palpation of the ribs (Greve and Dyson, 2015)and the mid-point between the tuber sacrale (TS) located from palpation of the TS (Figure 1). An index card (152mm x 103mm) was fixed to the side of the horse to provide a reference point for creation of a scale that enabled scale measurements to be calculated during subsequent digital analysis (Tabor, 2015).

CCSM treatment

Horses were required to be standing in a baseline position: standing square with the left and right limbs aligned such that the toes were level and the limbs parallel, and with the head in a neutral position, defined as the mouth being level with the point of shoulder (Berner et al., 2012), before CCSM commenced. The CCSM technique consisted of two parts:

1) the (right or left) forelimb was flexed with the carpus at an angle of ninety degrees so the horse was maintained in a tripod position, followed by
2) the application of a cranial to caudal force to the forehand via the ipsilateral point of the shoulder until the perceived end of range feel was achieved and sustained for five seconds.

Standardisation of the force applied during manual therapy and classification of the end of range of movement was determined using Maitland's Principles (Maitland et al., 2001). The CCSM technique applied force to generate range of motion through the neutral zone of unrestricted movement in to the elastic zone to the point where the tissues gradually stiffened to limit motion. CCSM ceased when the continuous application of force was met with a firm resistance and no elasticity in the tissues was felt and no further movement occurred (Maitland et al., 2001). As it is common for the CCSM technique to compromise a horse's balance and cause them to step back at the end of CCSM, the caudal pressure was released and raised foot was returned to the floor before this occurred. The horse was repositioned in a square posture before the contralateral forelimb was raised and the subsequent CCSM began. No rest periods occurred between right and left CCSM. Each subject had the treatment technique applied twice for the left and the right forelimb in a randomised order.

Horses were recorded completing each CCSM using the video application of an iPad Mini (Apple ipad mini model A1432, Apple, California, USA; 60 frames/sec). The iPad was fixed to a tripod stand at a height of 120cm, 3 metres lateral and perpendicular to the side of the horse the CCSM was being applied to. This facilitated horse and handler movements to be recorded. Head position was maintained in a neutral position with the horse's mouth level with the point of the shoulder (Berner et al. 2012) by a consistent handler using a headcollar and lead rope.

Data analysis

Videos were uploaded to the Dartfish™ Express movement analysis tool (version 3.0.2; Dartfish Inc., Fribourg, Switzerland) for subsequent kinematic analysis (Chen, 2015;

Mills, 2015). Thoracolumbar depth (mm) and angle (°), individual thoracolumbar angle and depth measurements at each spinal level were taken for two standardised positions: a) baseline when the horse was standing in a neutral position and b) at maximum spinal flexion during CCSM; measurements were taken from static images as validated by Dyson et al. (2011). A horizontal line was drawn from the marker on the withers to the marker mid-TS, vertical plumb lines were then plotted from each spinal marker (T10 to L3) to bisect this horizontal line, enabling the thoracolumbar depth of each marker to be measured (Figure 2a). The thoracolumbar depth recorded in the baseline position was subtracted from the thoracolumbar depth recorded at maximum flexion during CCSM to give the difference in thoracolumbar depth, for each spinal marker, for the right and left conditions. Thoracolumbar angle was also measured; straight lines were plotted from the withers marker and the mid-TS marker to each individual spinal marker allowing the angle between them to be measured for the baseline and maximum flexion positions (Tabor and Randle, 2013) (Figure 2b). Thoracolumbar angles for the right and left conditions for each spinal marker were calculated by subtracting the baseline thoracolumbar angle from the thoracolumbar angle recorded at maximum flexion during CCSM.

Data were exported to Microsoft Excel, version 2010 (Microsoft, Redmond, Washington, USA) prior to statistical analysis using Statistics Package for the Social Sciences (SPSS) Version 23. The median and interquartile range (IQR) for the differences in thoracolumbar depth and angle for individual spinal markers for the baseline condition and during CCSM were calculated for the cohort. The sum mean and SD, and median and IQR for the differences in thoracolumbar depth and angle were calculated across all spinal markers for the right and left conditions.

The data were tested for normality (Kolmogorov-Smirnof test) and the datasets met normal assumptions when tested (Field. 2009). A series of paired t-tests determined if significant differences occurred in maximum thoracolumbar depth and maximum thoracolumbar angle for each marker, between the baseline and maximum flexion position, and between the sum mean change in ROM for thoracolumbar depth and maximum thoracolumbar angle for the right and left conditions (significance: $P<0.05$).

Results

There was no difference between effect created during the application of the CCSM technique via the left or right forelimb on thoracolumbar angle (mean±sd left foreleg: 153.0±5.6°; right foreleg: 154.0±5.0°; $P>0.05$) or thoracolumbar depth (mean±sd left foreleg: 73.0±23.6mm; right foreleg: 77.0±26.0mm; $P>0.05$). However, the application of the CCSM technique did produce a significant increase in the mean change of ROM for the thoracolumbar angle of 7° ($P<0.0001$) and a significant decrease in the mean change of ROM for the thoracolumbar depth of 16mm ($P<0.0001$) between the baseline and maximum flexion measurements across the cohort (Table 1). The significant differences observed were consistent at the level of individual spinal markers with the exception of thoracolumbar angle at L1 where increases in angles did not differ significantly (Table 1). Differences in flexion of between 5 and 9 degrees occurred on application of CCSM at T10, with 6-7 degrees at T13, 4 degrees at T17 and 6 degrees at both L3 and L5 (Table 1).

Table 1: Mean and standard deviation values and Paired t-test results for differences in thoracolumbar depth (millimetres: mm) and thoracolumbar angle (degrees: °) during right and left application of craniocaudal spinal mobilisation in 13 horses. FL: forelimb; SD: standard deviation; P: probability; TL: thoracolumbar.

Difference in thoracolumbar angle and depth were calculated across the group for each individual spinal marker. Paired t-tests identified if the difference in angle (°) and depth (mm) recorded were significant for left and right CCSM. Bold P values denote significant results.

	Thoracolumbar depth (mm)							Thoracolumbar angle (^{0})						
Marker	baseline	left CCSM	difference	P value	right CCSM	difference	P value	baseline	left CCSM	difference	P value	right CCSM	difference	P value
T10	101.4±24.1	86.3±27.5	15.1±3.4	**P=0.005**	82.8±23.1	18.5±4.4	**P=0.004**	155.8±5.0	160.2±7.1	4.5±2.1	**P=0.02**	160.8±4.7	4.7±0.5	**P=0.0001**
T13	97.2±22.6	77.0±25.5	20.2±2.9	**P=0.01**	72.4±26.3	4.6±0.8	**P=0.004**	168.8±8.0	176.0±7.5	7.2±0.5	**P= 0.0001**	174.6±7.1	1.4±0.4	**P= 0.02**
T17	81.7±21.2	64.5±26.4	17.2±5.2	**P=0.02**	59.5±25.7	4.9±0.7	**P=0.003**	175.0±6.0	178.6±3.6	3.6±2.4	**P=0.05**	179.5±4.5	0.8±0.8	**P=0.01**
L1	61.6±20.5	45.0±16.6	16.6±37.1	**P=0.0008**	40.2±21.5	4.8±4.8	**P=0.002**	178.9±5.5	182.3±3.4	3.4±2.2	P>0.05	178.5±0.5	3.8±3.7	P>0.05
L3	36.9±11.6	27.8±18.0	9.1±6.4	**P=0.01**	27.2±17.3	0.7±0.6	**P=0.01**	179.0±4.0	183.2±4.2	4.2±0.3	**P=0.001**	183.2±4.2	0.2±0.1	**P=0.02**

Discussion

The CCSM technique produced flexion of the thoracolumbar spine in accordance with the bow and string theory of equine spinal function (Slijper, 1946). CCSM positions the horse in a tripod position, which requires the increased recruitment of postural musculature to sustain balance in a reduced base of support (Clayton, 2004). The application of the cranial to caudal force applied through the shoulder further challenges stability and this force is thought to cause a caudal movement of the trunk versus the hind limb, simulating protraction increasing the tension in the vertebral bow, creating flexion. Therefore increased tension occurs in the bow as a result of increased abdominal activity alongside protraction of the hind limbs, creating traction of the hindlimb retractors and epaxial musculature leading to the increase in flexion observed. Further evaluation of the individual components of the CCSM technique is warranted to support theories to explain why the technique creates spinal flexion.

This preliminary study has shown that the application of the CCSM may be used to produce spinal flexion of the thoracolumbar spine which is a region commonly associated with pain and poor performance (Zimmerman et al. 2012). Two metrics were used in this study to measure spinal flexion. The reduction in the maximum thoracolumbar depth and increase in the maximum thoracolumbar angle, demonstrates flexion (Berner et al., 2012, van Weeren et al., 2010 and Rhodin et al., 2005). However, flexion was not consistently shown for all individual spinal markers. These inconsistencies may be explained by a number of factors including elements of the methodology such as errors in marker placement, unknown clinical features such as osseous anomalies (Stubbs et al., 2006) and pathology (Vanderbroek et al., 2016), suboptimal conformation or subclinical discomfort caused by external factors such as rider asymmetry or ill-fitting tack (Denoix et al., 1998). Alternatively the inconsistencies could potentially relate to normal anatomical variation in flexion at different points of the spine (Licka and Peham, 1998). Further research is needed to evaluate the effect of the CCSM on performance measures in the horse such as stride length as a functional outcome measure and range of spinal motion during gait as a dynamic outcome measure.

Limitations

This study examined the effect of the CCSM on ridden asymptomatic horses, repeating the study to compare the effect of the CCSM on the spinal kinematics in two populations differentiated by the presence or absence of spinal pain is warranted. It should also be noted that changes in spinal kinematics were associated with a single application of the CCSM technique, and the lack of repeated measures precluded intra-reliability assessment. This study used one physiotherapist to standardise the application of the technique to each horse however experimenter error could also introduce inconsistencies into the data if the application was not consistent. Future studies incorporating repeated applications of the CCSM technique by the same physiotherapist are warranted to ensure the reliability and consistency of the method. In addition, research evaluating the consistent application of the CCSM method between different practitioners is also warranted to ensure potential effects are not associated with an individual's translation of the technique. Likewise, evaluation of the duration of post-treatment effects of CCSM is worthy of consideration, to inform their inclusion within equine treatment regimes.

Conclusion

There is evidence to justify and clinically reason the use of the CCSM in the management of thoracolumbar pathology in the horse where the desired goal of treatment is to increase thoracolumbar flexion.

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Conflict of interest

No conflicts of interest apply to this work.

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Figure headings and legends

Figure 1. Thoracolumbar depth measurement

Markers were positioned on the dorsal spinous processes (DSP) at the highest point of the wither, T10, T13, T15, T17, L1 ,L3 ,L5 and the mid-point between the tuber sacrale. Horses were positioned according to the defined protocol and static digital images were then taken in neutral stance: baseline position (as pictured) and at the point of maximum flexion during craniocaudal spinal manipulation (CCSM). The white card fixed to the left shoulder provided a reference point to ensure computer generated measurements were to scale.

Figure 2. Thoracolumbar angle measurement

Using Dartfish, a straight line was plotted from the wither marker to the individual marker of interest, e.g. T10 as illustrated in the image, and a second straight line was drawn from this marker to the marker situated between the tuber sacrale to allow the thoracolumbar angle (the arc on the diagram) to be measured. Baseline and maximum flexion during CCSM measurements were taken for all thoracic and lumbar markers.